

Shell morphotypes of the invasive gastropod *Rapana venosa* in the Northern Adriatic Sea

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Abstract

The present paper reports the shell morphological differences among specimens of the alien whelk *Rapana venosa* collected along the Northern Adriatic coast, in the framework of a study supported by the Italian Ministry of the Environment dealing with the risk of bioinvasion by *R. venosa*. Three hundred individuals of the whelk were collected in three localities, two in the Emilia Romagna region (Goro and Cesenatico) and one in the Marche region (Fano) during May, June and July 2004. Samples collection was performed in collaboration with squid fishermen. Shell colour and morphology were recorded for each individual. The analysis revealed the existence of 42 different combinations of characters (morphotypes), some of which were prevalent for each of the three localities of collection.

Such a variability in a narrow area suggests that the presence of *Rapana venosa* in the Northern Adriatic could result from a multiple supply of larvae from different part of the world, thus to a constant propagule pressure which originated different subpopulations of the whelk, rather than to a single successful event of introduction (first occurrence was recorded in the 70's). Genetic analysis will be necessary to confirm this hypothesis and clarify the origin of *R. venosa* population in Northern Adriatic Sea.

Riassunto

Il presente lavoro si occupa di analizzare la variabilità morfologica del nicchio di *Rapana venosa*, gasteropode asiatico alloctono in Nord Adriatico.

I dati sono stati raccolti nell'ambito di un progetto di ricerca finanziato dal Ministero dell'Ambiente Italiano, il cui scopo era quello di quantificare il rischio ecologico di bioinvasione del gasteropode lungo le coste dell'Adriatico Settentrionale.

In Maggio-Luglio 2004 sono stati raccolti in collaborazione con alcuni pescatori di seppie 300 esemplari viventi di *Rapana venosa*, in tre località: Goro (FE), Cesenatico (FC), Fano (AN). Colorazione e morfologia della conchiglia sono state analizzate per tutti gli esemplari raccolti. L'indagine ha dimostrato l'esistenza di 42 morfotipi (possibili combinazioni di caratteri morfologici conchigliari). Le tre località risultavano inoltre contraddistinte da popolazioni con morfotipi conchigliari diversi, caratteristici di ciascuna località d'indagine. Tale variabilità fenotipica, manifestata su un'area di indagine relativamente limitata, suggerisce come la presenza del gasteropode possa essere attribuita a continui eventi di introduzione da una o più località d'origine. Un costante apporto di nuovo materiale genetico avrebbe quindi prodotto, in Adriatico Settentrionale, subpopolazioni differenti caratterizzate da un'elevata variabilità fenotipica del nicchio. Solo un adeguato studio di genetica di popolazione, supportato da tecniche di biologia molecolare, potrebbe confermare le nostre ipotesi e fornire indizi utili a identificare le principali rotte di introduzione di questa specie aliena in Italia.

Key words

Rapana venosa, bioinvasions, morphology, Northern Adriatic Sea.

Introduction

Rapana venosa (Valenciennes, 1846) is a muricid gastropod native to the Sea of Japan, the Yellow Sea, the East China Sea and the Bohai gulf (Tsi *et al.*, 1983; Chung *et al.*, 1993). During the last 50 years this species spread over its native biogeographic range colonizing in Europe different localities of the Black Sea, the Marmara Sea, the Aegean Sea, the Adriatic Sea, the Northeastern Atlantic Sea (Drapkin, 1953; Ghisotti, 1974; Gouilletquer, 2000; Koutsoubas & Voultsiadou-Koukoura, 1991; Zolotarev, 1996), in North America the Chesapeake Bay (Harding & Mann, 1999), and in South America the Samborombon and Montevideo bays (Pastorino *et al.*, 2000) (Fig. 1).

Rapana venosa establishment is facilitated by its ecological fitness. In fact, the whelk is characterised by high fertility

(Chung *et al.*, 1993), fast growth rates (Ciuhcin, 1984; Harding & Mann, 2001) and tolerance to extreme environmental conditions such as low salinity, hypoxia and water pollution (Zolotarev, 1996; Mann & Harding, 2000). Larvae are planktonic for 14-80 days, a period which could grant an easy transfer in ballast water by transoceanic ships (Mann & Harding, 2000). The first record of *R. venosa* in Italy occurred offshore the Ravenna harbour in 1973 (Ghisotti, 1974). In the following years this species spread along the Northern Adriatic coast from Trieste to Ancona; recent studies showed that a conspicuous population of the gastropod lives by the shores of Cesenatico (Emilia Romagna) (Savini *et al.*, 2004).

In 2004 the Italian Ministry of the Environment supported a project aiming to identify the distribution of the whelk in the Northern Adriatic Sea. The description of *R. venosa* morphological characteristics (shell mor-

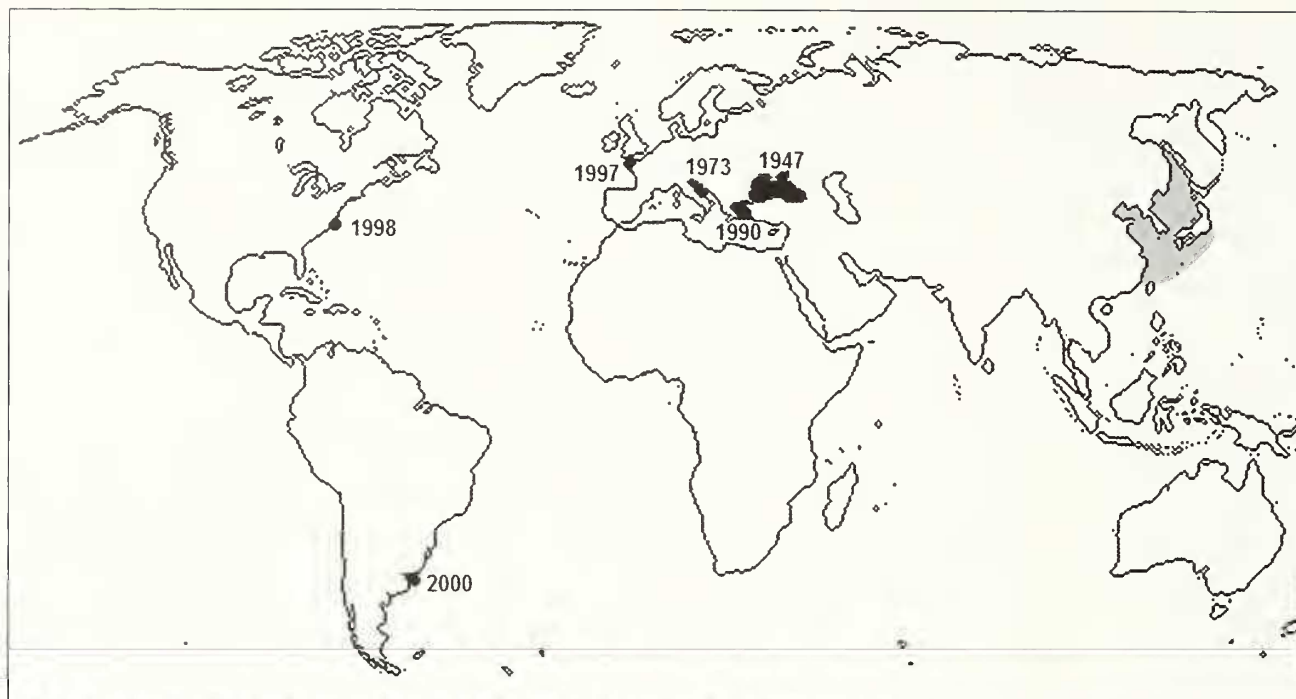


Fig. 1. World distribution of the gastropod *R. venosa*. In grey: native distribution, in black: introduced.

Fig. 1. Distribuzione mondiale del gasteropode *R. venosa*. In grigio: distribuzione nativa, in nero: località di introduzione.

phology, and shell colour) was one of the task of the project and constitutes the subject of the present paper. Our hypothesis is that subpopulations of the gastropods are present in the Northern Adriatic, each one showing characteristic phenotypical traits; differences could be caused by different events of introduction and subsequent crossbreed amongst specimens coming from other localities in the world.

Materials and methods

In May-July 2004, a total of 6594 living specimens of *Rapana venosa* was collected in three localities: Goro, Cesenatico (Emilia Romagna Region) and Fano (Marche Region).

Sample collection was performed in collaboration with squid fishermen that employ bottom fishing nets. These nets, locally called “cogolli”, act as efficient traps for *R. venosa* individuals, during the reproductive season. *R. venosa* reproductive individuals need hard substrata for laying egg cases, thus largely utilise bottom fishing nets and remain trapped in them. Fishing nets used for this study were laid about 1 mile offshore the coast, covering a bottom area of about 10 km² in each locality.

A random subsample of 100 *R. venosa* individuals for each sampling locality (total: 300 specimens) was selected for morphological analysis. The following fenotypic traits were analysed:

- Outer shell coloration: whitish/light brown, brown, dark-brown (Fig. 2 a);
- Shell aperture coloration: yellow-whitish, orange, red, dark striped (Fig. 2 b);
- Shell stripes: unevident/evident (Fig. 2 c);
- Shell spines: well pronounced/non pronounced (Fig. 2 d);

Marginal teeth: well pronounced/non pronounced (Fig. 2 e).

R. venosa specimens collected in Goro and Fano were characterised by a prevalence of whitish/light brown (54 and 60% of the total sample respectively), whereas in Cesenatico the dominant colour of the shell was brown (55%) (Fig. 3 a). In Goro and Cesenatico the orange colour of the aperture was highly dominant (95%), in Fano a red aperture was more common (57%) (Fig. 3 c). In Goro, 74% of the samples showed evident shell stripes, in Cesenatico and Fano shells with both evident and unevident stripes were observed (54 e 51% respectively) (Fig. 3 b). In Fano, 85% of the samples did not have pronounced spines on the shell; in Cesenatico and Goro about half of the samples showed pronounced shell spines (51% and 53% respectively) (Fig. 3 d). Finally, most of the specimens collected did not have pronounced marginal teeth on the aperture margin: Goro (83%), Cesenatico (90%), Fano (74%) (Fig. 3 e).

A total of 42 possible shell characteristic combinations (morphotypes) were identified, the most represented combinations (frequency > 3%) are reported in Tab. 1.

The most represented morphotype in Goro was the F2 (24%): whitish/light brown, evident stripes, orange aperture, pronounced spines and non pronounced marginal teeth; in Cesenatico the dominant morphotypes were: F1 (16%) (whitish/light brown, evident stripes, orange aperture, non pronounced spines, non pronounced marginal teeth) and F5 (16%) (brown shell, unevident stripes, orange aperture, pronounced spines, non pronounced marginal teeth); in Fano F7 (14%) (whitish/light brown, evident stripes, red aperture, non pronounced spines, non pronounced marginal teeth) and F8 (15%) (whitish/light brown, non evident stripes,

red aperture, non pronounced spines, non pronounced marginal teeth).

Discussion and conclusions

Clear morphological differences between *R. venosa* shells collected in Fano and Cesenatico have been observed. In Fano whelks showed whitish/light brown shell with red aperture, whereas in Cesenatico brown to dark brown shells with orange aperture. Goro's speci-

mens had intermediate characters with a prevalence of whitish shells with orange aperture. Green *et al.*, 2001 compared morphological traits of native (Yellow Sea, Korean Straits) and introduced populations of *R. venosa* in the Black Sea and Chesapeake Bay highlighting morphological differences amongst the three populations. From a genetics point of view both mitochondrial and nuclear DNA analysis conducted on the same specimens (Gensler *et al.*, 2001) demonstrated a limited genetic variability in the introduced populations of Che-

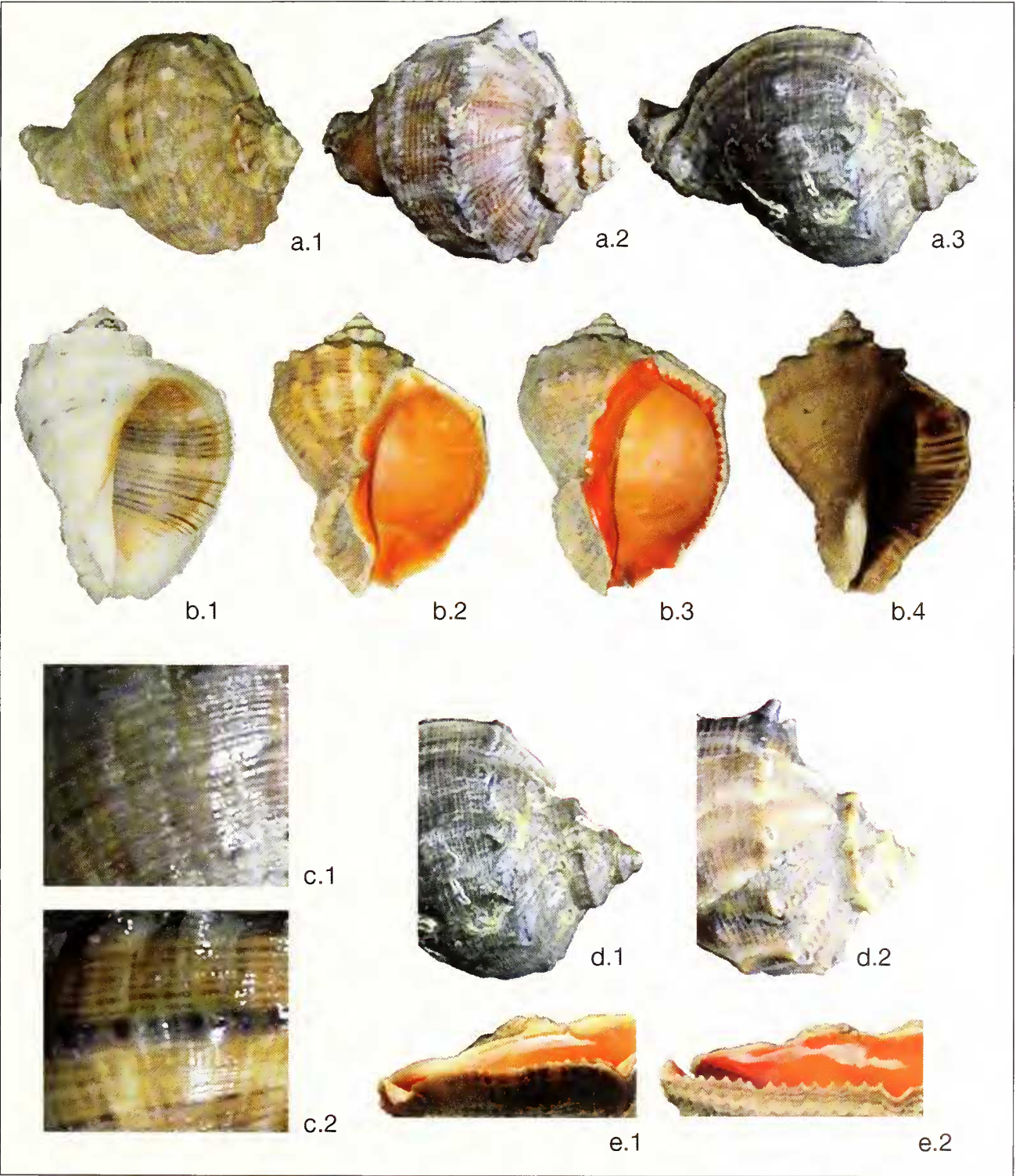


Fig. 2. Shell phenotypic traits of *R. venosa* shell.(a1-a3): outer shell colouration, (b1-b4): shell aperture colouration, (c1, c2): shell stripes, (d1-d2): shell spines, (e1-e2): aperure marginal teeth.

Fig. 2. Tratti fenotipici della conchiglia di *R. venosa*. (a1-a3): colorazione esterna della conchiglia, (b1-b4): colorazione dell'apertura conchigliare, (c1, c2): striature, (d1-d2): spine, (e1-e2): denti marginali dell'apertura.

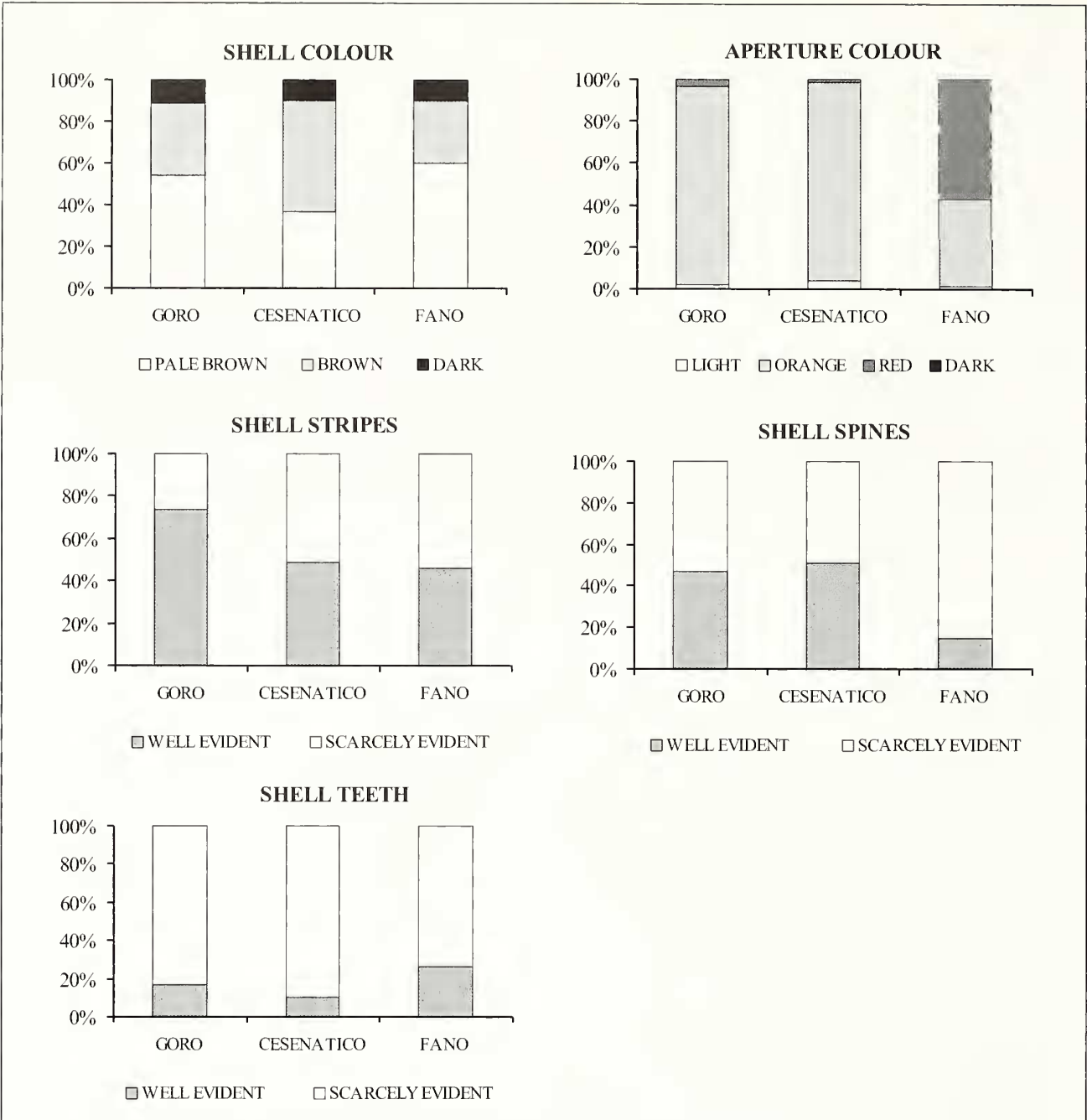


Fig. 3. Percentage of occurrence of the different shell phenotypic traits in *R. venosa* specimens of Goro, Cesenatico and Fano.

Fig. 3. Frequenza dei tratti fenotipici della conchiglia di *R. venosa* negli esemplari di Goro, Cesenatico e Fano.

| | Shell Colour | Shell Stripes | Aperture Colouration | Shell Spines | Marginal Teeth |
|----|--------------|------------------|----------------------|------------------|------------------|
| F1 | Light brown | Well evident | Orange | Scarcely evident | Scarcely evident |
| F2 | Light brown | Well evident | Orange | Well evident | Scarcely evident |
| F3 | Brown | Scarcely evident | Orange | Scarcely evident | Scarcely evident |
| F4 | Brown | Well evident | Orange | Scarcely evident | Scarcely evident |
| F5 | Brown | Scarcely evident | Orange | Well evident | Scarcely evident |
| F6 | Brown | Well evident | Orange | Well evident | Scarcely evident |
| F7 | Light brown | Well evident | Red | Scarcely evident | Scarcely evident |
| F8 | Light brown | Scarcely evident | Red | Scarcely evident | Scarcely evident |
| F9 | Light brown | Scarcely evident | Witish | Scarcely evident | Scarcely evident |

Tab. 1. *R. venosa* most represented shell morphotypes (frequency > 3%) in Goro, Cesenatico and Fano.

Tab. 1. Morfotipi conchigliari caratteristici (frequenza > 3%) degli esemplari di *R. venosa* raccolti a Goro, Cesenatico e Fano.

sapeake Bay and the Black Sea compared to the native one and higher similarities between the European and North American specimens. In particular the Black Sea population, which presents very low morphological and genetic variations, could be an example of the “founder effect” (Mayr, 1964), i.e. the establishment of a new population by a few original founders (in an extreme case, by a single fertilized female) which carries only a small fraction of the total genetic variation of the parental population. On the contrary, the phenotypic plasticity observed in our study does not seem to support the hypothesis of a “founder effect” in the Northern Adriatic introduced population. In the Northern Adriatic Sea, the morphological heterogeneity of shell characters could be the phenotypic expression of a higher genetic diversity, that could be explained by multiple introductions of larvae from different areas of the world, providing an additional supply of genes to the original founder population, and lowering genetic drift. An additional reasonable hypothesis could consider multiple introduction events from a single locality, along a well consolidated commercial route, that could provide as well the Adriatic population with periodical “waves” of new genetic material. Further genetic analysis on the Northern Adriatic subpopulations of *Rapana venosa* are needed to support our observations and clearly define the origins and ways of transfer for this alien species.

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